

New Processes for the Estimation of Military Airframe Costs

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Since the end of the Cold War, large-scale reductions in defense allocations have prompted both the Department of Defense and Congress to place an increasingly high premium on the affordability of weapon systems. Yet many aircraft contractors and government program managers have long maintained that government cost estimators have consistently overestimated the costs of such systems by virtue of their reliance on outdated forecasting methodologies. The generation of more timely cost-estimating models would thus appear to form the cornerstone of sound acquisition policy.

In *Military Airframe Costs: The Effects of Advanced Materials and Manufacturing Processes*, RAND researchers Obaid Younossi, Michael Kennedy, and John C. Graser address this issue by updating existing cost-estimating methodologies in the critical area of military airframes. After providing basic background information on the various materials that are used to produce airframe structures, the authors discuss the relative advantages of both traditional and evolving manufacturing techniques. Drawing from an industry survey as well as from part-manufacturing data, they then analyze how the cost of producing airframe structures varies with material mix, manufacturing technique, and part geometric complexity. The data thus derived are then integrated with those from a comprehensive historical cost database to yield a more accurate means of generating airframe cost projections.

AIRFRAME MATERIALS AND MANUFACTURING PROCESSES: AN OVERVIEW

Although many material properties have a bearing on the production of military airframes, two of the most critical properties are strength and stiffness, especially in relation to weight. Most airframe parts require exceptional strength and stiffness if they are to withstand the loads to which they are subjected during flight. At the same time,

low airframe weight boosts aircraft performance in such pivotal areas as range, payload, acceleration, and turn rate.

Advanced composite materials such as carbon-epoxy, carbon-bismaleimide, and carbon-thermoplastic offer precisely these advantages in military airframe applications. Specifically, such composites boast mechanical properties that are comparable to those of metal, including strength and stiffness, but at the same time are of lighter weight. Composites can also be designed and built with more strength and stiffness in some directions than in others, allowing them to be tailored to the directional loads a part is expected to bear. Finally, composite materials lend themselves to unitization—that is, to the use of one integrated part in place of several smaller parts that must be fastened together into one subassembly.

At the same time, composites have also been associated with a host of disadvantages, the most significant of which are higher design, fabrication, and raw material costs. The design flexibility composites afford, for example, carries with it the associated drawback of increased design complexity.

In recent years, however, a number of new composite manufacturing techniques that may offset these deficiencies have come to the fore. The traditional hand layup process, for example—in which workers must manually stack individual layers (plies) on a tool in order to form a composite part—is rapidly being complemented and, in some cases, supplanted by techniques such as automated fiber placement, in which a machine lays down plies, and resin transfer molding, in which parts are formed in a complex die. Both of these technologies make it possible to fabricate highly complex composite parts less expensively and with significantly better tolerances than would be feasible by hand.

New metal manufacturing processes also hold the promise of reducing airframe costs. High-speed machining, for example, has the potential to both lower the cost and increase the complexity of parts that can be fabricated from aluminum. Similarly, hot isostatic-press investment casting has the capacity to greatly enhance the properties of parts cast from titanium. These and other manufacturing techniques must be taken into account if future methodologies are to accurately forecast the manufacturing costs of military airframe structures.

UPDATING COST-ESTIMATING METHODOLOGIES

In their efforts to generate a more accurate means of estimating military airframe costs, the authors drew from two primary data sources. First, they surveyed the military airframe industry to obtain estimates of how aircraft production costs varied with airframe structure material mix. Put more precisely, estimates were collected on the relative costs—expressed in labor hours expended per pound of material—of seven different airframe materials broken down into six labor categories. Second, the authors analyzed actual part-level data from recent aircraft manufacturing efforts to determine the effect of material mix, manufacturing process, and geometric complexity of parts on airframe manufacturing costs. The data thus collected were then integrated with those in a historical cost database to yield an overall methodology for forecasting airframe costs.

In general, the authors found that the costs associated with manufacturing composite airframe parts remain higher than those associated with comparable metal parts despite the advent of new manufacturing processes and technologies. Estimates drawn from the airframe industry, for example, indicated that the labor hours expended in the manufacture of composite parts were consistently higher than those for aluminum across all labor categories examined, often by as much as 60 to 80 percent. At the

same time, the authors found composite parts to be significantly less costly to manufacture than what historical data had suggested would be the case.

The authors' analysis of part-level data also confirmed that advanced manufacturing techniques require fewer labor hours per pound than do conventional fabrication methods, both for metals and for composites. Indeed, in their analysis of the cost of a notional future fighter aircraft, the authors found that the application of new manufacturing processes could potentially reduce recurring manufacturing labor hours by as much as 17 percent. These data clearly indicate that airframe manufacturing hours should decrease as modern fabrication techniques are adapted for use within the airframe industry.

Two caveats should be borne in mind in any effort to project future airframe costs. First, a high degree of uncertainty is currently associated with future military aircraft production levels. Indeed, every military aircraft program in existence today has generated some degree of controversy in light of post-Cold War decreases in defense expenditures. Thus, the incentive for industry to embrace new manufacturing techniques—and hence to incur the capital and training costs that such techniques would entail—remains low. Second, as aircraft designs evolve and their performance requirements become more stringent, the question arises as to whether aircraft structures will require greater complexity, thereby offsetting some of the cost reductions that have been forecast or achieved to date.

The research outlined in this book will provide cost estimators and engineers with a variety of factors that should prove useful in adjusting or creating estimates of airframe costs based on parametric estimating techniques. Cost analysts must, however, remain abreast of changes in industry practice if they are to accurately gauge the potential effects of new processes and materials on future airframe design.

RAND research briefs summarize research that has been more fully documented elsewhere. This research brief describes work done for RAND's Project AIR FORCE; it is documented in *Military Airframe Costs: The Effects of Advanced Materials and Manufacturing Processes*, by Obaid Younossi, Michael Kennedy, and John C. Graser, MR-1370-AF, 2001, 168 pp., ISBN 0-8330-3036-1, available from RAND Distribution Services (Telephone: 310-451-7002; toll free 877-584-8642; FAX: 310-451-6915; or email: order@rand.org). Abstracts of all RAND documents may be viewed on the World Wide Web (www.rand.org). Publications are distributed to the trade by NBN. RAND® is a registered trademark. RAND is a nonprofit institution that helps improve policy and decisionmaking through research and analysis; its publications do not necessarily reflect the opinions or policies of its research sponsors.

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1700 Main Street, P.O. Box 2138, Santa Monica, California 90407-2138 • Telephone 310-393-0411 • FAX 310-393-4818
1200 South Hayes Street, Arlington, Virginia 22202-5050 • Telephone 703-413-1100 • FAX 703-413-8111
201 North Craig Street, Suite 102, Pittsburgh, Pennsylvania 15213-1516 • Telephone 412-683-2300 • FAX 412-683-2800

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